

1 **Supplementary Material**

2

3 **S1. Analysis of national scale heat action plans**

4

5 Heat action plans in France, England, the Netherlands, British Columbia, Japan, and Italy rely on
6 three core activities: warning systems, institutional frameworks, and measures for vulnerable
7 populations (See Table S1, S2). Studies from Italy and France describe national programs that use
8 threshold-based warnings, registries, and active surveillance to reach at-risk groups. In Japan, a
9 ministry-led approach employs Wet Bulb Globe Temperature metrics and local government
10 support to trigger alerts and guide community outreach. In England, plans associated with the
11 National Health Service suffer from fragmented communication and limited frontline integration,
12 while work in British Columbia emphasizes interagency partnerships, including indigenous and
13 community organizations. Dutch examples stress institutional protocols in care settings and the
14 need for locally adapted research. Several evaluated lesson categories appear directly transferable
15 to other settings (Table S3). Papers indicate that early warning systems, targeted support for
16 vulnerable groups, and multi-channel communication strategies hold high transferability. Cross-
17 sectoral governance and systematic evaluation receive moderate transferability ratings, whereas
18 integration of mental health measures appears less supported. These concrete activities and
19 documented lessons offer a transferability framework for heat action plan development based on
20 clear meteorological triggers, defined institutional roles, and tailored community engagement.

21

22 Table S1. Characteristics of included studies.

| Study | Country/Region | Study Focus | Heat Action Plan Components | Methodology |
|-------------------------|-------------------------------------|--|---|---|
| de 'Donato et al., 2018 | Italy | Temporal change in heat-related mortality post-national heat plan | No mention found in abstract | Time series analysis; distributed lag non-linear models; qualitative survey |
| Signer et al., 2023 | Canada (British Columbia, Victoria) | Community resilience and adaptation post-2021 heat dome | Vulnerable population identification; community engagement | Case study |
| Salagnac, 2007 | France | Lessons from 2003 heatwave | No mention found in abstract | No mention found |
| Deegan et al., 2022 | Canada (British Columbia) | Heat Alert and Response System (HARS) development in rural community | Early warning, meteorological triggers, communication, engagement, vulnerable groups, healthcare mobilization | Qualitative; mixed methods |
| Michelozzi et al., 2010 | Italy | National program for heat-health prevention | Early warning, meteorological triggers, communication, engagement, vulnerable groups, healthcare mobilization | Mixed methods |
| Pascal et al., 2021 | France | Challenges to heat warning systems | Early warning, meteorological triggers, communication, engagement, vulnerable groups, healthcare mobilization, evaluation | Mixed methods |

| | | | | |
|--|---------------------|---|---|--|
| Kunst and Britstra, 2013 | Netherlands | Evaluation of Dutch national heat plan in care institutions | Vulnerable group identification, cooling measures, protocols, staff training | Qualitative with quantitative data |
| Hong et al., 2022 | France, South Korea | Comparative review of Paris and Seoul Heat Action Plans | Early warning, vulnerable group support, communication, engagement | Comparative case study |
| Heudorf and Schade, 2014 | Germany | Mortality in Frankfurt post-Heat-Health Action Plan | Early warning, communication, engagement, vulnerable groups, healthcare mobilization | Comparative case study; quantitative |
| Scortichini et al., 2018 | Italy | Temporal variation in heat effect post-plan | No mention found in abstract | Quantitative (distributed lag non-linear models) |
| Brooks et al., 2024 | England | Health system resilience during 2019 heatwave | No mention found in abstract | Qualitative |
| Boyson et al., 2014 | England | Evaluation of National Heatwave Plan in hospital | No mention found in abstract | Qualitative |
| Vachat et al., 2004 | France | Adaptation to heatwaves post-2003 | Early warning, communication, French National Heatwave Plan (Plan Canicule) | No mention found |
| Pavanello et al., 'Mortality, Temperature, and Public Adaptation Policy' | Italy | Impact of national program on mortality | Public awareness, warning systems, hospital protocols | Comparative case; quasi-experimental |
| Tonouchi, 2013 | Japan | Heat Disorder Information System | Early warning, meteorological triggers, communication, engagement, vulnerable groups, healthcare mobilization | Qualitative |

| | | | | |
|---|---------------------------|---|---|----------------------------------|
| Pascal et al., 2006 | France | Development of Heat-Health Warning and Watch System (HHWWS) | Early warning, meteorological triggers, communication, engagement, healthcare mobilization | Mixed methods |
| McLean et al., 2018 | Canada (British Columbia) | Establishing heat alert thresholds | Early warning, meteorological triggers, communication, engagement, vulnerable groups, healthcare mobilization | Systematic review; mixed methods |
| Bittner et al., 2013 | Not specified in abstract | Policy development/implementation in Europe | Indoor heat reduction, urban planning, surveillance | Qualitative |
| McLean et al., 'Establishing Appropriate Hot Weather Alerting Criteria' | Canada | Hot weather alerting criteria | Early warning, meteorological triggers, local adaptation | Quantitative (time-series) |
| Howarth et al., 2025 | United Kingdom | Coping vs. resilience in 2022 heatwave | No mention found in abstract | Qualitative |
| Sario et al., 2011 | Italy | Heat-Health Warning and Watch System models and prevention | Early warning, communication, vulnerable groups, prevention activities | Mixed methods |
| Berry et al., 2014 | Canada | Heat Alert and Response System in urban/rural communities | Mobilization, alert protocol, response plan, communication, evaluation, prevention | Comparative case; mixed methods |
| Dwyer et al., 2022 | Europe, India, Australia | Evaluation methods for Heat Action Plans | Heat Warning System, Heat-Health Action Plan, universal heat index | Systematic review |
| Bittner et al., 2014 | Europe (18 countries) | Assessment of Heat Action Plans in WHO Europe | 8 core elements (lead body, alert, | Systematic review |

| | | | | |
|--|--|--|--|--|
| | | | information, indoor heat, vulnerable groups, preparedness, urban planning, surveillance) | |
|--|--|--|--|--|

23

24

25 Table S2. Heat Action Plan Development Activities.

| Study | Country/Region | Warning Systems | Institutional Framework | Vulnerable Population Measures |
|--------------------------|-------------------------------------|---|---|--|
| de 'Donato et al., 2018 | Italy | No mention found | National heat plan, survey of measures | No mention found in abstract |
| Signer et al., 2023 | Canada (British Columbia, Victoria) | No mention found | Municipal, provincial, and health authority collaboration | Strategies for vulnerable groups, community engagement |
| Salagnac, 2007 | France | No mention found | No mention found | No mention found in abstract |
| Deegan et al., 2022 | Canada (British Columbia) | Heat alert thresholds, British Columbia Centre for Disease Control triggers | Health authority, municipal, First Nations, community organizations | Identification and engagement of vulnerable groups |
| Michelozzi et al., 2010 | Italy | City-specific Heat-Health Warning and Watch System | National program, local adaptation | Registries, active surveillance, targeted prevention |
| Pascal et al., 2021 | France | Joint Santé publique France/Météo-France system | National plan, feedback loops | Registries, call centers, management plans |
| Kunst and Britstra, 2013 | Netherlands | No mention found | National heat plan, institutional protocols | Protocols, cooling, staff training for vulnerable groups |
| Hong et al., 2022 | France, South Korea | Early warning systems | National plans, urban/social policy integration | Support for vulnerable, infrastructure expansion |
| Heudorf and Schade, 2014 | Germany | National warning system | Local authorities, public health services | Targeted information, inspections, visits |
| Scortichini et al., 2018 | Italy | No mention found | National heat plan | No mention found in abstract |
| Brooks et al., 2024 | England | No mention found | National Health Service, hospital-based | No mention found in abstract |
| Boyson et al., 2014 | England | No mention found | Hospital management | No mention found in abstract |

| | | | | |
|---------------------|---------------------------|--|---|--|
| Vachat et al., 2004 | France | Alert system, vigilance map | French National Heatwave Plan (Plan Canicule) | No mention found in abstract |
| Pavanello et al. | Italy | Warning systems | National program, hospital protocols | No mention found in abstract |
| Tonouchi, 2013 | Japan | Wet Bulb Globe Temperature-based system | Ministry of Environment, local governments | Focus on elderly, seminars, guidebooks |
| Pascal et al., 2006 | France | Heat-Health Warning and Watch System, 4-level response | National action plan, interagency | Real-time data, not explicit |
| McLean et al., 2018 | Canada (British Columbia) | High-low-high thresholds | British Columbia Centre for Disease Control, Environment and Climate Change Canada, Health Canada | Sub-analyses for risk groups |

26

27

28 Table S3. Transferability Framework Application.

| Lesson Category | Countries of Origin | Transferability Level | Implementation Requirements |
|---------------------------------|--|------------------------------|--|
| Early warning systems | France, Italy, Japan, Canada, Netherlands | High | Meteorological data, health surveillance, local adaptation |
| Vulnerable population targeting | France, Italy, Netherlands, Canada, Japan | High | Registries, outreach, tailored communication, staff training |
| Cross-sectoral governance | France, Italy, Netherlands, Canada, United Kingdom | Moderate | Interagency agreements, clear roles, stakeholder engagement |
| Evaluation and surveillance | France, Italy, Europe | Moderate | Real-time data, feedback loops, resource allocation |
| Communication strategies | All | High | Multi-channel messaging, media engagement, tailored content |
| Local adaptation | All | High | Needs assessment, resource mapping, community engagement |
| Mental health integration | Global (few plans) | Low | Evidence base, resource allocation, tailored interventions |

29

30

31 **Supplementary material references**

- 32 Filippo Pavanello, Giulia Valenti, Irene Mammi, and Francesco Vona. “Mortality, Temperature,
33 and Public Adaptation Policy: Evidence from Italy *,” n.d.
- 34 A. Casanueva, Annkatrin Burgstall, S. Kotlarski, A. Messeri, M. Morabito, A. Flouris, L. Nybo,
35 C. Spirig, and C. Schwierz. “Overview of Existing Heat-Health Warning Systems in
36 Europe.” *International Journal of Environmental Research and Public Health*, 2019.
- 37 A. Kunst, and R. Britstra. “Implementation Evaluation of the Dutch National Heat Plan Among
38 Long-Term Care Institutions in Amsterdam: A Cross-Sectional Study.” *BMC Health
39 Services Research*, 2013.
- 40 Allison Stewart-Ruano, Raenita Spriggs, E. Lawrance, Alessandro Massazza, Alexandra
41 Czerniewska, Alejandro Sáez Reale, Joy Shumake-Guillemot, Katherine M. Keyes,
42 Yoshira Ornelas Van Horne, and Robbie Parks. “A Critical Gap in Addressing Mental
43 Health in Heat-Health Action Plans Worldwide.” *Current Environmental Health Reports*,
44 2025.
- 45 C. Brimicombe, James J. Porter, C. Napoli, F. Pappenberger, R. Cornforth, C. Petty, and H. Cloke.
46 “Heatwaves: An Invisible Risk in UK Policy and Research.” *Environmental Science and
47 Policy*, 2021.
- 48 C. Howarth, Niall McLoughlin, Sara Mehryar, Ellie Murtagh, Andrea Armstrong, and James
49 Porter. “Boiling Point: Short-Term Coping with Heatwaves in the UK Is Not Enough.”
50 *Environmental Research Letters*, 2025.
- 51 Chris Boyson, Sarah Taylor, and Lisa Page. “The National Heatwave Plan – A Brief Evaluation
52 of Issues for Frontline Health Staff.” *PLOS Currents*, 2014.

53 Emily J. Tetzlaff, Nicholas Goulet, Melissa Gorman, Gregory R. A. Richardson, Paddy M.
54 Enright, Robert D. Meade, and Glen P. Kenny. “Hot Topic: A Systematic Review and
55 Content Analysis of Heat-Related Messages During the 2021 Heat Dome in Canada.”
56 *Journal of Public Health Management and Practice*, 2023.

57 F. de'Donato, M. Scortichini, M. D. Sario, A. D. Martino, and P. Michelozzi. “Temporal Variation
58 in the Effect of Heat and the Role of the Italian Heat Prevention Plan.” *Public Health*, 2018.

59 F. Matthies, and B. Menne. “Prevention and Management of Health Hazards Related to
60 Heatwaves.” *International Journal of Circumpolar Health*, 2009.

61 Fariha Hasan, Shayan Marsia, K. Patel, Priyanka Agrawal, and J. Razzak. “Effective Community-
62 Based Interventions for the Prevention and Management of Heat-Related Illnesses: A
63 Scoping Review.” *International Journal of Environmental Research and Public Health*,
64 2021.

65 Franziska Baack, Johannes Halman, Joanne Vinke-de Kruijf, G. Özerol, and Stefan M. M. Kuks.
66 “Dutch Municipalities Tackling Climate Change Adaptation to Heat Stress Through
67 Mainstreaming Across Sectors.” *Environmental Science & Policy*, 2024.

68 G. S. Martinez, Chisato Imai, and Kanako Masumo. “Local Heat Stroke Prevention Plans in Japan:
69 Characteristics and Elements for Public Health Adaptation to Climate Change.”
70 *International Journal of Environmental Research and Public Health*, 2011.

71 G. S. Martinez, V. Kendrovski, M. A. Salazar, F. de 'Donato, and M. Boeckmann. “Heat-Health
72 Action Planning in the WHO/Europe: Status and Policy Implications.” *Environmental
73 Research*, 2022.

74 G. Sanchez Martinez, V. Kendrovski, and F. de 'Donato. "Heat and Health Prevention in European
75 Region Under a Changing Climate: The Urgent Need for a Faster Roll-Out of Heat-Health
76 Action Plans (HHAPs)." *ISEE Conference Abstracts*, 2022.

77 H. A. Grewe, S. Heckenhahn, and B. Blättner. "[Health Protection During Heat Waves: European
78 Recommendations and Experience in Hesse]." *Zeitschrift Für Gerontologie Und Geriatrie*
79 *(Print)*, 2014.

80 H. Deegan, J. Green, Sylvia El Kurdi, Michelle Allen, and S. Pollock. "Development and
81 Implementation of a Heat Alert and Response System in Rural British Columbia."
82 *Canadian Journal of Public Health*, 2022.

83 I. Dwyer, S. J. E. Barry, I. Megiddo, and C. White. "Evaluations of Heat Action Plans for Reducing
84 the Health Impacts of Extreme Heat: Methodological Developments (2012–2021) and
85 Remaining Challenges." *International Journal of Biometeorology*, 2022.

86 J. Salagnac. "Lessons from the 2003 Heat Wave: A French Perspective," 2007.

87 K. Vanderplanken, J. V. Loenhout, and P. Hazel. "The Health Impact of Heat Waves in Europe:
88 Insights from National Plans and Key Informant Interviews." *European Journal of Public*
89 *Health*, 2019.

90 K. Vanderplanken, P. van den Hazel, Michael Marx, A. Shams, D. Guha-Sapir, and J. V. van
91 Loenhout. "Governing Heatwaves in Europe: Comparing Health Policy and Practices to
92 Better Understand Roles, Responsibilities and Collaboration." *Health Research Policy and*
93 *Systems*, 2021.

94 Kathleen E. McLean, Melissa Macdonald, and S. Henderson. "Establishing Appropriate Hot
95 Weather Alerting Criteria for British Columbia, Canada." *ISEE Conference Abstracts*,
96 2018.

97 Kathleen E. McLean, R. Stranberg, Melissa Macdonald, Gregory R. A. Richardson, T. Kosatsky,
98 and S. Henderson.
99 “Establishing Heat Alert Thresholds for the Varied Climatic Regions of British Columbia,
100 Canada.” *International Journal of Environmental Research and Public Health*, 2018.

101 Katya Brooks, O. Landeg, S. Kovats, M. Sewell, and E. OConnell. “Heatwaves, Hospitals, and
102 Health System Resilience in England: A Qualitative Assessment (Summer 2019).”
103 *European Journal of Public Health*, 2024.

104 Kristie Signer, Summer Formosa, and Tanya Seal-Jones. “Building Community Resilience: The
105 City of Victoria's Approach to Climate Change Adaptation and Extreme Heat Response.”
106 *Journal of Business Continuity and Emergency Planning*, 2023.

107 M. Boeckmann, G. S. Martinez, and Kendrovski. “Organizing the Institutional Public Health
108 Response to Heat Under Climate Change: A Scoping Review.” *European Journal of Public
109 Health*, 2019.

110 M. D. Sario, M. Leone, Adele Lallo, M. Davoli, and P. Michelozzi. “Preparedness and Response
111 Plans to Reduce the Health Impact of Heat Waves in Italy,” 2011.

112 M. Pascal, K. Laaidi, M. Ledrans, E. Baffert, C. Caserio-Schönemann, A. Tertre, Jacques Manach,
113 S. Médina, J. Rudant, and P. Empeur-Bissonnet. “France’s Heat Health Watch Warning
114 System.” *International Journal of Biometeorology*, 2006.

115 M. Pascal, R. Lagarrigue, Anouk Tabai, Isabelle Bonmarin, Sacha Camail, K. Laaidi, Alain Le
116 Tertre, and Sébastien Denys. “Evolving Heat Waves Characteristics Challenge Heat
117 Warning Systems and Prevention Plans.” *International Journal of Biometeorology*, 2021.

118 M. Scortichini, F. Donato, M. D. Sario, A. D. Martino, M. Davoli, and P. Michelozzi. “OP II – 6
119 Temporal Variation in the Effect of Heat and the Role of the Italian Heat Prevention Plan.”
120 *Occupational and Environmental Medicine*, 2018.

121 M-I Bittner, Eva Franziska Matthies, D. Dalbokova, and B. Menne. “Are European Countries
122 Prepared for the Next Big Heat-Wave?” *European Journal of Public Health*, 2014.

123 M-I Bittner, F. Matthies, D. Dalbokova, and B. Menne. “Is Europe Prepared for the Next Big
124 Heatwave,” 2013.

125 Michihiko Tonouchi. “Heat Disorder Information System for Japan in 2012,” 2013.

126 P. Berry, Anna Yusa, Toni Morris-Oswald, and A. Rogaeva. “Heat Alert and Response Systems
127 in Urban and Rural Communities in Canada,” 2014.

128 P. Michelozzi, F. D. de’ Donato, A. Bargagli, D. D’ippoliti, M. De Sario, C. Marino, P. Schifano,
129 et al. “Surveillance of Summer Mortality and Preparedness to Reduce the Health Impact of
130 Heat Waves in Italy.” *International Journal of Environmental Research and Public Health*,
131 2010.

132 PD Dr. U. Heudorf, and M. Schade. “Heat Waves and Mortality in Frankfurt Am Main, Germany,
133 2003–2013.”
134 *Zeitschrift Für Gerontologie Und Geriatrie (Print)*, 2014.

135 R. Vachat, S. Planton, and M. Gillet. “ADAPTATION TO HEAT WAVES OCCURRENCE IN
136 FRANCE 1,” 2004.

137 Sara Mehryar, Candice Howarth, and Declan Conway. “Heat Risk Interdependencies in the UK:
138 Implications for Adaptation.” *Earth's Future*, 2025.

139 Siyu Yu, Kin Long Lei, Dongying Li, You Joung Kim, Mio Nemoto, Sarah Gatson, Makoto
140 Yokohari, and Robert Brown. “Plan Integration for Urban Extreme Heat: Evaluating the
141 Impacts of Plans at Multiple Scales in Tokyo, Japan.” *Urban Climate*, 2024.

142 Yong-jin Hong, You-ki Min, Sangduk Lee, and Sungmin Choi. “Expanded Orientation of Urban
143 Public Health Policy in the Climate Change Era: Response to and Prevention of Heat Wave
144 in Paris and Seoul: A Brief Review.” *Iranian Journal of Public Health*, 2022.

145